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AUTO DATA DIGITALS

MOD. 1640 DS

houston instrument corporation

DIGITAL VOLTMETER

MODEL 2640 DS

SERIAL NO. _____

AUTO DATA DIVISION Bellaire, Texas 77401
Houston Instrument Corporation

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D. C. DIGITAL VOLTMETER SPECIFICATIONS

AUTO DATA MODEL 2640

Range	10 Volt	100 Volt	1000 Volt
Accuracy	± 1 digit	± 1 digit	± 1 digit
Input Resistance	1000 meg ⏦	10 meg ⏦	9 meg ⏦
Resolution	± 0.1 digit	± 0.1 digit	± 0.1 digit

Number of digits:	4
Polarity change:	Automatic
Ranging:	Manual or Automatic
Balance Time:	1 Second maximum, ½ Second Average
Input:	Floating
Sensitivity:	Adjustable to 1, 10, or 100 digits
Dimensions:	19 x 18 x 7
Weight:	45 lbs.

INSTRUMENT WARRANTY

AUTO DATA DIVISION, Houston Instrument Corporation, warrants, unconditionally, for one year from date of shipment, each instrument manufactured by it to be free from defects in material and workmanship. Its liability under this warranty is limited to servicing or adjusting any instrument returned by the original purchaser to the factory for that purpose and to replace any defective parts thereof. Tubes, fuses, and other expendable material are exempt from warranty. If the fault has been caused by misuse, damage in shipment or abnormal conditions of operation, repairs will be billed at cost. In this case, any estimate will be submitted before the work is started. If any fault develops, the following steps should be taken:

(a) Notify us, or our representative, giving full details of the difficulty and include the model and serial numbers. On receipt of this information, we will give you service data or shipping instructions.

(b) On receipt of shipping instructions, forward the instrument, prepaid, to the factory or our authorized representative. A firm estimate of any charges will be made before any work begins, provided the instrument is not covered by the warranty.

AUTO DATA DIVISION
Houston Instrument Corporation
4950 Terminal Avenue
Bellaire, Texas 77401

PRELIMINARY OPERATING INSTRUCTION MANUAL
FOR
AUTO DATA MODEL 2640 DIGITAL VOLTMETER
SERIAL NO. _____

SECTION I

GENERAL INFORMATION

1-1 INTRODUCTION

This handbook of operating instructions covers the Model 2640 Digital Voltmeter. The material presented in Sections I through V covers general characteristics, installation, theory of operation, operation and maintenance.

1-2 INSTRUMENT DESCRIPTION

The Model 2640 is an automatic continuous balanced 4-digit reed switch Digital Voltmeter using continuous balance logic. It offers major advances in readability, flexibility, precision and dependability. In operation, the instrument may be used as an automatic ranging, automatic polarity digital voltmeter, or the proper range may be manually selected by operation of a front panel control. The instrument measures DC voltages from 1 millivolt to 999.9 volts with an accuracy ± 1 digit. The instrument incorporates a number of features unique to AUTO DATA equipment. The sensitivity of the instrument is controllable from the front panel, sensitivities being 1 digit, 10 digits, or 100 digits. The front panel NULL indicating meter displays the error signal existing between the input voltage being measured and the number indicated in the instrument readout. The graduations of this NULL meter resolve the last significant instrument digit into 10 increments. The front panel in-line, edge-lighted readout displays measured value, polarity and decimal point. Extensive use of plug-in construction facilitates ease of maintenance.

1-3 INSTRUMENT FUNCTION

This automatic self-balancing potentiometer is used as a general purpose, wide range, highly accurate voltage measuring instrument. It finds application in development and testing laboratories as well as in general purpose checkout test stations.

1-4 EQUIPMENT SUPPLIED

This instrument is supplied complete with all transistor plug-in circuit boards and other parts necessary for operation. The input cable for the instrument is also supplied.

1-5 DIMENSIONS

The Model 2640 is mounted on a standard 19 inch relay rack panel, 7 inches high. The cabinet depth is 18 inches.

SECTION II

INSTALLATION

2-1 UNPACKING

Instruments are separately packed and are shipped in cardboard cartons or wooden crates, depending on the requirements of the purchaser and the common carrier.

2-2 INSPECTION

Visually inspect the instrument for shipping damage. Remove the top and bottom chassis covers and make certain that the plug-in circuit boards, chopper, and other components are firmly seated in their sockets.

2-3 POWER INPUT

The 2640 is designed to operate on 105 to 125 volts, 60 cycle single phase power. The maximum demand is approximately 60 V.A.

2-4 QUICK CHECK

The following procedures serve to verify the instrument operational performance:

(a) Connect the input test cable to the rear panel input connector and connect the clip leads together.

(b) Connect the power cable to a source of 115 volt AC 60 cycle power and turn the front panel power switch to the ON position. The readout display should light.

(c) Set the front panel switches as follows: Set the RANGE switch to the AUTO position, set the SENSITIVITY switch to the 1 position, set the CONTROL switch to the TRACK position. The display should now read all zeros and the decimal point should appear between the first and second digits from the left.

(d) Now connect the clip leads of the input test cable to a source of voltage between zero and 10 volts. The instrument should balance and indicate the value and polarity of the applied voltage. Now reverse the 2 clip leads. The instrument should read within 1 digit of the previous reading but of opposite polarity.

(e) Apply a voltage between 10 volts and 100 volts to the instrument. The instrument should balance and the decimal point should be between the 2nd and 3rd digits from the left. Reverse the clip leads and the instrument should again balance within 1 digit of the previous reading but of opposite polarity.

(f) Apply a voltage between 100 and 1000 volts. The instrument should perform as in Sections D & E, but the decimal point should be between the 3rd and 4th digits from the left.

SECTION III

THEORY OF OPERATION

3-1 GENERAL

(a) Instrument Operation. AUTO DATA automatic Digital voltmeter is a self-balancing potentiometer using continuous balance logic. Basically the instrument operates as follows:

The output of a precision 10 volt DC reference supply is fed into an 18 step precision resistive divider. The first 9 resistors in this divider have a value R. The second 9 resistors have a value 10R. Thus, we have voltages 0 to 9 volts in 1 volt steps and 0 to 9/10 volt in 1/10 volt steps. Opposite poles of all these reed switches are connected together. By closing the appropriate reed switch any voltage from 0 to 9.9 volts in 1/10 volt steps may be obtained. A second divider similar to the first divider is fed from a precision 1/10 volt reference. It consists also of 18 steps and these steps produce voltages in 1 millivolt steps up to 99/1000 of a volt.

The output of the divider associated with the 10 volt reference and the divider associated with the 1/10 volt reference are connected in series and thus by closing appropriate switches any voltage from 0 to 9.999 volts in 1 millivolts steps may be obtained. A series of reed switches are also provided to reverse the 1/10 and 10 volt reference supplies and thus reverse the polarity of the outputs from the dividers.

It should be noted that the total number of resistors in the divider is equal to the sum of the number of digits in each decade, that is, 36. The use of the dual reference supplies eliminates the need for compensation resistors or double divider schemes. The output of the digital divider is now compared against the unknown input signal to the DIGITAL VOLTMETER. This is done by the error amplifier which is effectively connected in series with the unknown voltage and the digital divider. The error amplifier through appropriate circuitry causes the digital counter to step and change the output of the digital divider until its output is equal to the unknown input voltages.

(b) Logic. The Digital Voltmeter consists of 5 basic sections, the bridge, counter, error amplifier, threshold detector, and clock. The bridge consists of a series of resistors and reed relays which produce a voltage from ± 9.999 millivolts in one millivolt steps. This voltage is compared against the unknown input voltage in the error amplifier. The output of the error amplifier goes to the

threshold detector. The threshold detector determines whether the unknown voltage is higher or lower than the bridge voltage or whether a NULL condition exists. The output of the threshold detector goes to two lines known as the UP and DOWN lines. When one of these lines is clamped to ground, that is, at zero volts, the counter is allowed to count in the appropriate direction. The counting proceeds as follows:

If the threshold detector indicates DOWN, that is, the DOWN line is at zero volts, the clock is allowed to reset the first decade, that is the 1 millivolt decade. If the DOWN condition continues to exist when there is a zero in the lowest decade, the clock is then allowed to reset the second lowest decade, that is, the 10 millivolts decade. Likewise, with the 100 millivolt decade and the 1 volt decade. If at the time when the 1 volt decade has been reset to zero the DOWN lines still indicates DOWN the clock is allowed to reverse the polarity of the bridge voltage. Once this has occurred the threshold amplifier will indicate UP or NULL and the meter will begin to count upward. This occurs as follows: The first decade counts 1, 2, 3, 4, 5 up to 9. Upon reaching 9 the second decade begins to count 1, 2, 3, 4, 5 on up to 9 and the 9 remains in the first decade. This sequence continues on until the time at which the meter has reached a NULL or the DOWN line calls for the counter. to count down. DOWN counting occurs in the same fashion as has been previously described. The operation of the counter as indicated above can be described by two rules.

(1) If the DOWN line is clamped at ground, that is, the meter is indicating that the bridge voltage is higher than the unknown voltage, then in any decade operation will be as follows: If all decades below the decade in question are at zero the next clock pulse will set that decade to zero. If the first decade is not at zero then it will be reset to zero.

(2) If the unknown voltage is greater than the bridge voltage then the UP line will be clamped to ground. Under this condition operation in any decade will be as follows: If all decades below the decade in question are at 9 then on each successive clock pulse the decade in question will move up one position until it too reaches 9. If the first decade is not at 9 it will begin to count one per clock pulse until it reaches 9.

These two rules describe the operation of the counter whenever the threshold amplifier indicates either UP or DOWN. If the threshold amplifier indicates NULL no clock pulses are allowed to trip the flip flops and the meter remains stationary.

3-2 HIGH Z AMPLIFIER

The high Z amplifier is shown on Schematic Drawing AE1183 in conjunction with its associated range attenuator. The high Z amplifier consists of a nuvistor cathode follower in which the cathode load is formed by transistor Q1. The output of this cathode is connected to an emitter follower formed by Q2. It will be noted that the emitter load for Q2 is furnished by resistors located on the carrier amplifier board.

Notice that the grid of the tube (pin 4) is at a very high impedance level. Since the transfer capacitance associated with the chopper C1 is only 3 mmfds., it is obvious that a very small capacitance shunted between C4 and ground attenuates the error signal, hence the location of component C1 is very critical.

DC supplies for the high Z stage are obtained by the decouplers located on the error amplifier board.

3-3 ERROR AMPLIFIER

Refer to Drawing BE-895. This error amplifier board receives an AC input signal from the output of the error chopper and the high Z stage. The error signal is applied to an attenuator composed of resistors R1, R2, and R3. Relays K1, K2, and K3 are energized in the 1, 10, and 100 SENSITIVITY switch positions respectively, changing effective gain as required to obtain 1, 10, and 100 digit sensitivity. The signal from the attenuator passes through a limiter, formed by resistor R4 and diodes CR1 and CR2, then through the input transformer into Q1 and Q2, which forms a differential amplifier. The output is isolated by emitter follower Q3 and is then coupled into another limiter formed by resistor R16 and diodes CR3 and CR4. The signal is then further amplified by another differential stage made up by transistors Q4 and Q5. The output of this section is then coupled into Q6, an emitter follower, and then into another limiter formed by R26, CR5, and CR6. Transistors Q7 and Q8 are the amplifier output stages providing two output signals 180° out of phase. Transistors Q9, Q10, Q11 provide power supply decoupling for the error amplifier.

3-4 LOGIC DRIVE CIRCUITS

These circuits are shown on Schematic Drawing BE1270. This board includes the following circuitry: The UP-DOWN threshold detectors, the clock, chopper drive, and meter demodulator. We shall consider each of these circuits in turn.

The chopper drive consists of transistors Q1 and Q2 which form a free running LC multivibrator. The load for the collectors of this multivibrator are furnished by a center tapped chopper coil winding. The DC collector voltage to the coil is supplied through resistor R5 which is by-passed by capacitor C-4. A portion of the output of the chopper drive multivibrator is coupled to transistor Q3 which forms a squaring amplifier. The output of the squaring amplifier is coupled through a gate which passes only positive signals through Diode CR1 to the base of Q4. Transistors Q4 and Q5 form a delay trigger. The delay time of this trigger is adjusted so that its output switches at the same time as the actual swtiching of the chopper contacts. The output of the first delay trigger formed by transistors Q4 and Q5 is connected to a gate which passes only negative pulses. This gate is formed by diode CR2 and is coupled to the base of Q6. Transistors Q6 and Q7 form a second delay trigger. The delay time of this trigger is adjusted such that the delay time corresponds to the dwell time of the chopper contacts. We noted that the collector of Q7 swings a full 40 volts. This is necessary in order to drive the demodulator.

It should also be noted that the first delay trigger formed by Q4 and Q5 is made up of NPN transistors. The second delay trigger formed by Q6 and Q7 are PNP transistors. This arrangement avoids the necessity for inverters after the first delay trigger in order to obtain the pulse of the proper polarity required to drive the second delay trigger. The voltage appearing in Q7 should be approximately a square wave. It should be exactly in phase or 180° out of phase with the error signal appearing at the output of the error amplifier. The output of the second delay trigger is coupled through capacitors C9 to the demodulator formed by transistors Q8 and Q9. It will be noted that Q8 is PNP transistor, and Q9 is an NPN transistor. Thus, these two transistors are in the conducting states on the opposite half of the cycle. Transistors Q10 and Q11 are emitter followers which serve to isolate the demodulator grom the output of the error amplifier. It will be recalled that the two error amplifier output lines are 180° out of phase, that is to say, when one line is positive, the other line will be negative and vice-versa. These lines alternate at the chopper frequency. Thus, the two voltages appearing at the emitter of Q10 and Q11 will likewise be 180° out of phase. Since transistor Q8 is only conducting 1/2 of the cycle and during the other half of the cycle the voltage appearing at the base of Q11 is allowed to flow through resistor R30 and R26 to capacitor C9. A net DC voltage will appear across C10. A similar argument applies to transistor Q9, resistor R31, and R27 and transistor Q10. Thus, a DC voltage proportional to the error signal appears across C9. It is fed to the NULL indicating meter. R29

is a trim resistor for adjusting the deflection of the NULL meter.

Also appearing on Drawing BE1270 are relays K1 through K4. These relays operate in pairs, that is, K1 and K3 are energized, K2 and K4 denergized, or K2 and K4 are energized, K1 and K3 denergized. Their effect is to reverse the polarity, at a given time, of the error signal. This is necessary for two reasons:

(1) To reverse the UP-DOWN logic when going from a positive unknown signal to a negative unknown signal.

(2) To reverse the meter deflection when going from a positive unknown signal to a negative unknown signal. It will be recalled that the NULL indicating meter indicates the absolute value of the error. That is to say, if the absolute value of the unknown voltage is greater than the reading of the digital voltmeter, the NULL indicating meter will indicate in a positive direction, regardless of whether the digital voltmeter is on ± polarity.

Next consider the threshold detectors which are also located on Drawing BE-1270. There are two threshold detectors: One for UP and one for DOWN signals. These two detectors are identical. The first detector, the UP detector, is formed by transistors Q20, Q21 and Q22. It is basically a Schmitt trigger which is triggered by approximately 1 volt. Since this Schmitt trigger is temperature sensitive, a diode CR9 is added in series with the input, thus producing a trigger level of approximately 5 volts. The output of one polarity of the error amplifier is coupled through capacitor C19, through the zener diode, to the input of this Schmitt trigger. If the error signal on a AC basis exceeds 5 volts, the Schmitt trigger will trip, causing transistor Q22 to conduct and cutting transistor Q21 off. This will allow transistor Q20 to conduct and clamp the UP line to ground. The DOWN threshold detector is formed by transistors Q17, Q18, and Q19 and operates in a fashion similar to that of the UP Schmitt trigger. It will be noted that these two triggers are triggered by negative going signals and hence, since the two error signal lines are 180° out of phase with each other, it will be found that only one line, that is, either the UP or the DOWN line will be in the clamped condition at a time. These two lines will reverse every cycle. If the signal out of the error amplifier is less than the threshold these lines will remain fixed in the unclamped position, which indicates a NULL.

The fourth section is a clock delay trigger and clock. A portion of the output signal of the squaring amplifier

Q3 is coupled through a positive gate to the base of transistor Q12. Transistors Q12 and Q13 form a delay trigger. The delay time of this trigger corresponds to the time from the rise of the voltage to the chopper coil to the mid point of the dwell time of the chopper contacts. The pulse from the output of this delay trigger is coupled through CR4 to the network formed by capacitors C16 and R40. This pulse serves to fire the blocking oscillator after a given number of cycles. Capacitor C6 is charged to a positive potential with respect to ground by the back pulse from the blocking oscillator. This holds transistor Q14 in the non-conducting state. Capacitor C16, then discharges due to current flowing through R40 and additionally due to current supplied through diode CR4. The time at which CR4 becomes approximately 4/10 of a volt negative with respect to ground, transistor Q14 will conduct, pulling current through T1, recharging C16 negative and producing a pulse through capacitor T18 to the base of transistor Q15. The output of Q15 is the clock pulse. This pulse is approximately 50 microseconds wide. Transistor Q15 is normally held in the conducting state by resistor R41. The pulse from the blocking oscillator serves to briefly cut this transistor off, that is, place it in the non-conducting state. It is the positive edge of this pulse which produces the triggering of the flip flop circuitry. Transistor Q16 is normally held in the non-conducting state by a positive voltage supplied by R44. If a negative voltage is supplied to either of the HOLD lines going to resistors R45 or R46, transistor Q6 will be forced into the conducting state. This will hold the clock line in the clamp condition, that is, at ground regardless of the trigger pulses from the blocking oscillator.

3-5 DECADE COUNTER

The counter consists of 4 identical boards. The schematic of these boards is shown in BE-633. Theory of operation is as follows: Each counter board consists of 4 flip flops. These flip flops are connected in series to act as a binary counter with the exception of the #2 flip flop. This flip flop is reset by the 4 flip flop and is set by resetting of the 1 flip flop. In addition the feedback path is provided between the 2 and the #2 flip flop. Counting occurs as shown in the coding table on Drawing BE-633. It will be noted that the counter recycles for every 10 counts applied to its input.

CR-10, CR-11 and CR-12 are a diode reset network. When the reset bus, pin 30, is clamped to ground all flip flops are reset to their zero position. This is the method used for resetting the counter as noted under counting when DOWN signals occur.

Also located on the flip flop board are 10 decoding matrix. These matrixes consist of R-1 through R-40. They convert the binary coded decimal information into straight decimal information for the relay driver and readout driver board.

The decimal output lines from the counter are pins 1 through 5 and pins 33 through 37. In operation all these lines will be negative except the line corresponding to the number at which the counter is set. The outputs of each flip flop are also brought out to pins on the board. These pins are 6, 7, 31, and 32. By grounding momentarily the appropriate pins the appropriate flip flops may be set. To reset the flip flops the reset line may be grounded at pin 30.

3-6 DRIVER AND UP-DOWN GATES

The Digital Voltmeter has a total of four identical relay and indicator driver boards. Each driver board has 10 line clamps, one for each of the 10 lines on the flip flop decoder matrixes. These line clamps drive the relay, indicator drivers of which there are 10. In addition, each driver board has an UP gate Q-23, a DOWN gate Q-21 and a reset clamp Q-22. The UP gate has a total of 3 inputs which go to the 9 drivers on the decades below the decade in question. On the lowest decade none of these 3 inputs is used. On the second decade, that is, the 10 millivolt decade one of these is used corresponding to the 1 millivolt 9 of these is used corresponding to the 1 millivolt 9 and so on with the 100 millivolt and 1 volt decades.

In addition this gate has an input from the UP line and an input from the inverted 9, that is, not 9 of the driver board. When all these lines are at zero volts the transistor is biased in the off condition and its collector is unclamped allowing clock pulses to flow through CR-3 and into the flip flop associated with the driver board under consideration.

The DOWN driver is similar to the UP driver. It again has a total of 3 inputs going to the zero drivers on lower decades. Like the UP driver none of these are used on the first decade and one is used on the second decade, two are used on the third decade and three are used on the fourth decade. In addition, this gate has an input from the DOWN line. It will be noted that the input going to the A. line which corresponds to the zero driver of the decade immediately below the decade in question consists of two resistors R-12 and R-13 and a capacitor

C-2. This capacitor serves to delay the zero signal from the next lower decade and prevents chain resetting of all flip flops with one clock pulse.

One additional input to this gate comes from the not zero signal obtained from the collector of Q-1. When all these lines mentioned above are at zero potential, the transistor Q-21 is biased in the off condition and clock pulses are allowed to flow through CR-2 and into the base of Q-22 causing Q-22 to conduct. This conduction clamps the collector of Q-22 to ground and resets the flip flop through diode CR-10, CR-12 and CR-13 located on the flip flop board. The decade associated with the driver board under discussion. It will be noted that the driver associated with the 4, 6, 8, 5, 3, and 1 digits are the same as the driver of the 2 and 7 digit. These are shown on the diagram as blocks.

3-7 THEORY OF THE RANGE COUNTER

The range counter is shown on Drawing BE835. It consists of the following parts:

UP range gate, DOWN range gate, 2 flip flops, 3 relay drivers and less than 10 scales plus circuitry.

The UP range gate consists of transistor Q11 and associated circuitry. When the digital voltmeter counter is at all 9s the voltage input to R37, R38, R39, and R40 will be zero volts. The UP line is indicating UP (recalling that the UP line reverses every chopper cycle). The input drawing line will be zero and the collector of Q11 will be negative. This will allow clock pulses to flow thru CR16, CR10 to the flip flop consisting of Q1 and Q2. The 2 flip flops consisting of Q1, Q2, Q3, and Q4 form the range counter. They are connected in a strictly binary fashion. The output of these flip flops goes thru a decoding matrix which drives the 3 relay drivers. The operation of the decoding matrix is shown in the table located on the range board schematic. It will be noted that there is not a unique driver for every combination of flip flops, that is to say, certain relay drivers are pulled in on two or more combinations of flip flop settings. This means that for certain range changes, 2 clock pulses are required instead of the normal one. Referring again to gate associated with Q11, it will be noted that when the highest range driver, that is, the number III range driver is pulled in. The junction of C8 and C9 will be held at zero volts, thru diodes CR6 and CR8. This prevents moving of the range counter due to UP range signals when the range counter is in the highest position.

DOWN ranging occurs as follows: The DOWN range gate is formed by transistor Q12 and its associated circuitry. If the digital voltmeter counter is at 1000 and the DOWN line is indicating DOWN, it will be found that the inputs to R46, R47, R48, and R50 will be continuously at zero volts, allowing the collector of Q12 to go negative during the non-conducting half of the clock cycle, allowing clock pulses to flow thru CR18 and CR11 into the range counter. It should be noted that these pulses cause the range counter to go in the same direction as do the UP pulses and these two sets of pulses are fed into the same input of the flip flop. Thus, if the digital voltmeter is on the #2 range and it is desired to go onto the #1 range, the range counter will count thru range 3 and return to the #1 range. That is to say, the instrument will range by counting around through the higher range and back to the lower range. If the range counter is in the #1 position, that is, on the lowest range, the collector of Q8 will be at ground potential and it will HOLD the junction of CR18 and CR11 at ground thru CR19. This will prevent DOWN range pulses from entering the range counter when the range counter is on the lowest range.

During automatic range operation it is necessary that the range counter DOWN range whenever a voltage of less than 1/10 full scale is reached on any range other than the lowest range. This operation is performed by transistors Q11 and Q14. Assuming that we are not on the 10 volt range and all zeros appear in the decade counter, the inputs to R18, R19, R20 and R22 will be at zero volts, thus causing Q13 to be in the non-conducting state. This will cause Q14 to conduct and to set off a 1 into the thousand decades by clamping the collector of the appropriate side of the 1 flip flop in the thousands decade. Assuming that the range counter is on the lowest range the junction of R21 and R22 will be at a negative potential and will supply a negative voltage thru R58 to the base of Q13. This will hold Q13 in the conducting state regardless the inputs to R55 thru R57 and hence Q14 will be held in the non-conducting state and will not effect the operation of the thousands decade. In addition, if the range switch is turned to the manual position, Q14 is held in the cut-off state since the collector of Q13 is held at ground potential thru diode CR20 thus the "less than 1/10 of scale surpressed" is in operative when pin 32 of the range board is grounded.

3-8 NULL DETECTOR INPUT POLARITY BOARD

NULL detector and polarity are shown on Drawing BE834. These consists of two essentially independent circuits. The polarity flip flop relay driver and the NULL detector.

First, let us consider the polarity flip flop and the associated relay drivers. Clock pulses to the flip flop

formed by Q2 and Q3 are controlled by the gate formed by transistor Q1. When the digital voltmeter is at all zeros and in the lowest range and a DOWN pulse occurs, the input to all resistors R1 through R5 will be at zero volts. These resistors are fed through resistors R52 thru R56. Diodes CR-22 thru CR26 connect to the relay digit driver lines, and from the range counter and the DOWN line of the threshold detectors. Assuming these lines are all at zero and a DOWN signal has occurred, the next clock pulse will be allowed to flow through CR16 into the flip flop, thus forcing it to change states. At this point, the UP-DOWN lines will be reversed by relays located on the threshold board and a DOWN signal will no longer occur. The output of the flip flop formed by Q2 and Q3 is fed through resistors R17 and R22 to the relay drivers. These relay drivers are identical to those associated with the decade counters and are described in the section on Counter Operation. Diodes CR23 through CR26 are gates to isolate the logic of the digital voltmeter from the relay coils. The actual logic current is supplied thru resistors R53 thru R56. Capacitor C1 serves to delay the zero signal from the lowest decade and prevent simultaneous resetting of the lowest decade of the digital voltmeter and polarity change on the same pulse.

The NULL detector is also part of this board. Transistor Q10 is an additional clock driver which furnishes clock signals at times when the clock line of the digital logic is held, Capacitor C6 is connected directly to the blocking oscillator. The clock pulse at the output of transistor Q10 is approximately 10 volts high and 50 microseconds wide. Assuming that the UP-DOWN lines are indicating a NULL condition, the junction of CR10 and CR11 will be at a negative potential. Clock signals are allowed to flow thru diode CR12 and capacitor C8 into a flip flop formed by Q12 and Q13. This will force transistor Q12 in the non-conducting state and will furnish a clock HOLD signal to the clock line. Assuming now that we are in the print mode and that the print switch has been depressed, current will flow through R47 into transistor Q15 and charge up capacitor C11 to the point in which transistors Q15 and Q14 go into the conducting states. This will pull in a NULL signal relay and produce a collector voltage at the collector of Q14 of approximately a tenth of a volt. Assuming that sometime during the time between which transistor Q12 goes into the non-conducting state and capacitor C11 is being charged, a non-null signal occurs. This will cause the junction of CR10 and CR11 to be clamped to ground and hence, transistor Q11 will be cut off. This will allow a negative signal to appear at the junction of the collector of transistor Q11 and R35 and clock pulses from the non-clamped clock line of Q10 will flow through diode CR9 and RESET the flip flop. Resetting of the flip flop will also rapidly discharge capacitor C11 thru diode

CR14 and prevent pull-in of the NULL relay. The flip flop formed by Q12 and Q13 is reset and the digital voltmeter will be unlocked and allowed to proceed until a NULL again occurs. When the NULL driver Q14 turns on it prevents further resetting of the NULL flip flop by clamping CR8 to ground.

The mode selector switch is in the track position, the digital voltmeter will under no conditions print, that is to say, the NULL detector never drops out. In the track position of the mode switch, operation is as follows:

The track line through pin 30 of the polarity-null detector board is held at ground by the mode switch and therefore the collector of Q13 and the base of Q15 are held at ground potential. This assures that transistor Q14 is always cut off and that the NULL flip flop formed by transistors Q12 and Q13 is in the non-null condition regardless of the condition of UP and DOWN lines when the mode switch is turned to the HOLD position, the HOLD line thru pin 33 of the polarity-null detector board will be at ground potential. This will force the flip flop formed by transistors Q8 and Q9 into the state with transistor Q8 in conducting also, transistor Q13 will be held in the conducting state thru diode CR4 and further the base of Q15 will be held at ground potential thru CR23. Pulling the base of Q15 to ground potential prevents Q14 from going into the conducting state. Holding of the collector Q8 at ground potential forces the collector of Q9 negative and supplies the negative signal to the clock HOLD line. If now the mode switch is switched to the print position, the output from Q8 will continue to clamp the clock line. If the START button is depressed, the ground signal will be applied thru CR5 to the collector of transistor Q8 forcing transistor Q8 into the conducting state and releasing the clock line and the base of Q15. Depressing the START button will also force the NULL flip flop formed by Q12 and Q13 to the non-null state, thru diode CR3. This will force the digital voltmeter into the unlocked condition and it will step until such time a NULL occurs. At that time, the NULL detecting sequence as previously described will occur. At the end of the NULL detecting sequence, the NULL relay will pull in as previously described and the NULL flip flop will be locked in the NULL state thru diode CR4. In order to restart the digital voltmeter for the next reading it is necessary to furnish a closure from pin 29 to ground.

SECTION IV

OPERATION

4-1 GENERAL

The Model 2640 Digital Voltmeter has been designed for maximum ease of operation. Front panel controls and adjustments have been minimized. This section will describe in detail the operation of the instrument.

4-2 PRECAUTIONS

(a) The Model 2640 Digital Voltmeter is supplied with an input cable assembly that will withstand high voltage. If any other input assembly is used care should be taken to make input connections with the input source voltage in a zero condition to eliminate electric shock hazards. Extreme caution must be exercised when measuring voltages in excess of 300 volts.

(b) Input circuits have been designed to withstand overloads and abuse, however it is possible to damage the instrument by extreme overload. When operating the instrument with manual ranging always select the proper range before making the input connections.

(c) The Model 2640 Digital Voltmeter is a "floating" instrument and can be used to measure voltages up to 500 volts DC or peak AC off ground. AC common mode voltages can introduce errors depending upon amplitude and frequency. There exists a small capacitance between the floating chassis and the panel. The effect of this capacitance in the test circuit must be considered.

(d) With the input signal far from NULL on the 10 volt range the input resistance of the instrument can be as low as 50,000Ω. The effect of this impedance on the circuit being measured should be considered before the instrument is connected to the test circuit.

4-3 CONTROLS

(a) RANGE SWITCH. The RANGE switch serves the function of placing the instrument in either the AUTOMATIC ranging mode of operation or the MANUAL ranging mode of operation. It also selects that manual range on which the instrument will operate.

(b) SENSITIVITY SWITCH. The SENSITIVITY switch adjusts the instrument NULL detector sensitivity to be either 1, 10, or 100 digits. This in effect makes the instrument a 4 digit, a 3 digit, or a 2 digit voltmeter. Thus, when measuring noisy signals the instrument sensitivity can be reduced in a calibrated manner and the readings indicated be valid though of reduce accuracy.

(c) CONTROL Switch. The CONTROL switch selects the balance mode of the instrument. In the TRACK position the printout capability is disabled and the instrument will operate as determined by the range and sensitivity switches. In the HOLD position the instrument clock is disabled and the instrument will not step to balance. In the PRINT position the instrument balance is initiated by pressing the PRINT button, and stops automatically when the machine reaches balance. After the null condition is reached a print command is initiated causing the value in the instrument readout to be printed on the external equipment. The instrument will not attempt to re-balance until the next print command is initiated.

4-4 DISPLAY

(a) DIGITAL Readout. The DIGITAL readout displays the value of the measured voltage as well as its polarity. The decimal point is automatically placed to indicate the range of the instrument. A new design, wide view, high intensity edge-lighted readout displays the value with a greater clarity and a wider viewing angle than previously available in instrument of this type.

(b) NULL Meter. The NULL meter is used to indicate the difference existing between the input voltage being measured and the internal digitally generated voltage. Points indicated -1 and + 1 represents an off NULL condition equivalent to 1 digit on the lowest decade being used. The graduations between zero and full scale further resolve this error signal into 10 increments. This in effect gives 5 digit resolution on a 4 digit instrument.

4-5 MEASUREMENT PROCEDURE

(a) AUTOMATIC Ranging. In the AUTOMATIC mode of operation when not using the printout capability the CONTROL switch is set to the TRACK position, the SENSITIVITY switch is set to the 1 position, and the RANGE switch is set to the AUTO position. The input cable test clips are connected to the circuit to be measured, and this circuit activated. The instrument starts at zero and measures up to balance increasing in range as becomes necessary. When the instrument comes to balance the value of the voltage being measured is displayed in the readout. Should the voltage being measured be noisy or be fluctuating, the instrument will not come to balance, but the last digit or digits will continue to "run around". Should this situation occur, the SENSITIVITY switch can be decreased to the 10 position, and the machine allowed

to balance. Should the instrument still "run around", the sensitivity can further be decreased by placing the SENSITIVITY switch on the 100 position.

(b) MANUAL Ranging. When a number of measurements are to be made on the same RANGE of the instrument, the RANGE switch can be placed on 1 of the 3 manual range positions. This eliminates the need for the instrument to reach all 9s before up ranging, and significantly speeds up the number of steps necessary to balance, increasing the effective instrument measuring speed. The operation of remaining front panel controls is uneffective by the position of the RANGE switch.

(c) PRINTOUT Operation. When it is desired to operate the instrument in a "printout" mode, the CONTROL switch is placed in the PRINT position. In this mode of operation the instrument RANGE and SENSITIVITY switches are set as previously explained and the measuring cycle initiated by depressing the print control button. The instrument goes through its balance cycle, balancing with the sensitivity determined by the SENSITIVITY switch, and in a ranging manner controlled by the RANGE switch setting. When the instrument reaches balance an internal NULL detector causes a printout signal to be initiated. This printout signal operates the external equipment. A further balance cycle will not be started until the print button is again depressed.

SECTION V

MAINTENANCE

5-1 GENERAL INFORMATION

The following should be kept in mind when working on or repairing this instrument.

(a) Do not remove or insert any printed circuit board into the unit with power applied.

(b) Great care should be exercised not to short any of the circuitry with power applied since this can easily destroy one or more transistors. Transistor circuitry is very susceptible to short-term overloads.

(c) Do not replace any fuse with a value larger than the value designated for that location.

(d) All light bulbs used in the readouts are 27 volt type 327, miniature lamps.

5-2 DIGITAL VOLTMETER TROUBLE SHOOTING

The following indicate general areas to investigate when the following instrument malfunctions occur:

(a) Digital Voltmeter runs around and will not come to balance. Possible causes are:

(1) Noisy input signal.

(2) Reference voltages are out of alignment. It is imperative that the low voltage and high voltage references be adjusted so that they are in good alignment. Misalignment of the references shows up particularly at transfer points.

(3) Logic mistakes, that is to say, the Digital Voltmeter does not follow the right sequence of steps on going from one number to another.

(4) Malfunction in the error amplifier.

(b) Digital voltmeter steps up to all 9 stops. Null meter is off scale. Possible causes are:

(1) Defective error amplifier.

(2) Excessive input signal.

(3) Defective polarity relays causing lack of reference voltage or defective polarity driver.

(4) Lack of reference voltage due to defective reference.

(5) Automatic ranging malfunction.

(6) On too low a manual range.

(c) Digital Voltmeter does not step at all, and the null meter is off scale.

(1) Defective clock or clock-hold circuitry.

(d) Digital Voltmeter does not step and null meter shows NULL.

(1) Broken input connection.

(2) Defective error amplifier.

(3) Defective power supply associated with the error amplifier.

(e) Digital Voltmeter does not come to zero but has between zero to 2 digits of stand-off.

(1) Readjustment of the carrier amplifier zero control.

(2) Defective carrier amplifier.

(f) Meter deflection is incorrect.

(1) Incorrect setting of carrier amplifier gain.

(2) Defective carrier amplifier.

(3) Incorrect setting of meter deflection potentiometer.

(4) Defective demodulator.

(g) One or more digital indicator lights fail to operate, but meter performs otherwise satisfactorily.

(1) Burned out light bulb.

(2) Poor contacts between the light bulb connector block located on the top of the readout and the bulb.

(h) One or more digital indicator lights do not light and the meter runs around at certain numbers.

(1) Defective driver transistor associated with the light which will not operate.

5-3 DETAILED TROUBLE SHOOTING OF THE INSTRUMENT

Perhaps the best clues to the area of malfunction in the digital voltmeter once the particular section malfunction has been isolated are furnished by the voltage measurements made at various points in the circuitry. Voltages may be easily measured on each board by utilizing an extender board. This allows easy access to the pins of the board in question. When attempting to isolate the trouble in a given section of the Digital Voltmeter, reference should be made to the section on Theory of Operation of that circuit and also to the appropriate schematic diagram. Many of the voltages are shown on the schematic drawings.

5-4 INSTRUMENT CALIBRATION

The following paragraphs outline the recalibration of the Model 2640 Digital Voltmeter. This instrument will require only infrequent recalibration. However, periodic check of the calibration is highly desirable to insure highest accuracy. The basic instrument reads between 1 milovolt and 9.999 volts. To read voltages in excess of this range, a two-position input attenuator is either automatically or manually inserted in series with the input signal. The basic calibration should be performed on the 10 volt range before the attenuator is calibrated.

(a) Calibration of the 10 volt range. To calibrate the 10 volt range, the instrument top and bottom inner and outer covers should first be removed. On the bottom of the decade boards at the front of the instrument, a wire jumper is placed between the wipers of the reed switches on the hundreds decade and the units decade. This jumper should be removed before attempting calibration.

Connect a voltmeter between the contact of the "9" reed switch on the thousands decade and the contact of the "9" reed switch on the hundreds decade, and apply power to the instrument. Adjust the trim pot on the top of the rear decade board until the voltmeter reads 9.900 volts. Connect the voltmeter between the contact of the units "9" reed switch and the tens "9" reed switch, and adjust the trim pot associated with this board until the voltmeter reads .099 volts. When these two adjustments have been made the Model 2640 is calibrated on the 10 volt range. Reconnect the jumper between the two decade boards.

(b) Calibration of the 1000 volt range. Place the Model 2640 in the 1000 volt position. Apply a known voltage near full scale to the input terminals. Adjust the 1000 volt range attenuator trim pot until the instrument indicates the voltage applied, and the null meter reads zero.

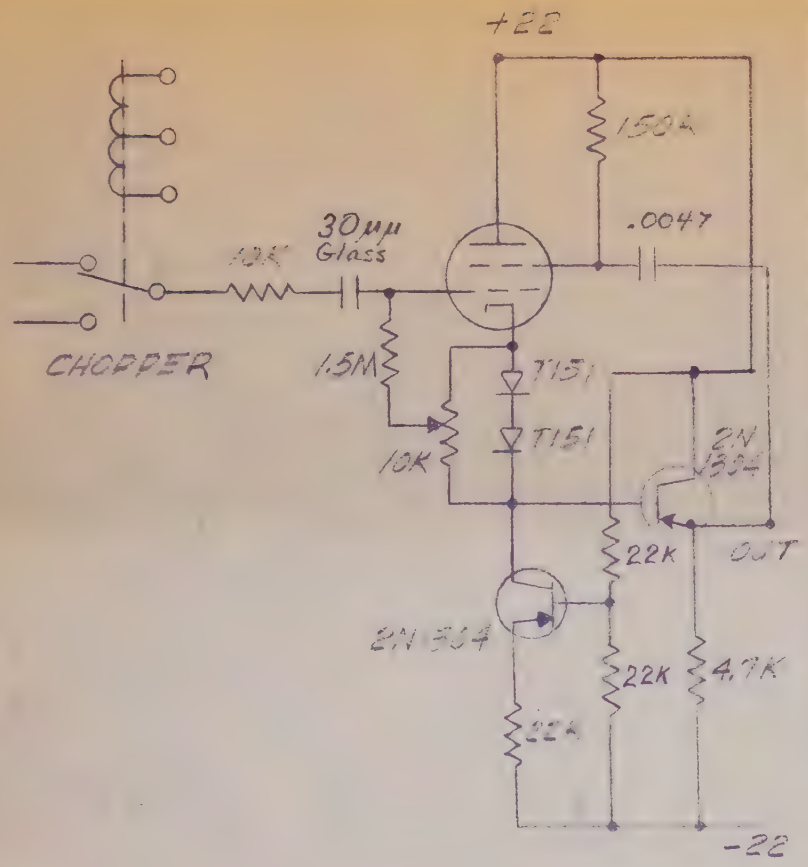
(c) Calibration of the 100 volt range. Place the range switch in 100 volt range. Apply a known voltage of between 90 and 100 volts to the input of the instrument. Adjust the trim pot associated with the 100 volt range until the Model 2640 indicates the voltage being applied and the null meter reads zero.

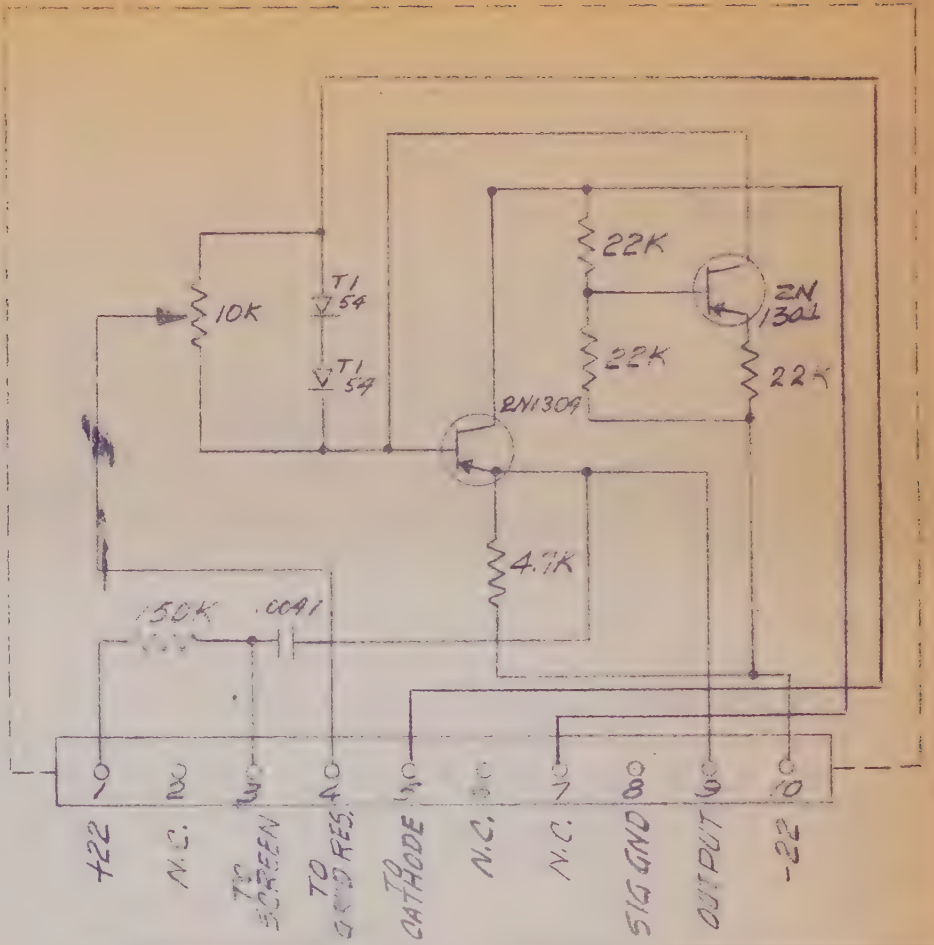
Completion of the four previously described operations constitutes recalibration of this instrument.

5-5 ADJUSTMENT OF CARRIER AMPLIFIER LIMITERS

Due to resistor tolerances and other factors it may be necessary to balance the limiting action of the carrier amplifier limiters. This may be done by inserting trim resistors in the positions located at R6, R14, R32 and R33. Adjustment and limiting can best be performed as follows:

To adjust the first limiter, proceed as follows: Connect the capacitor of approximately ½ microfarad to the junction of C1 and CR1. Connect an oscilloscope to the collector of Q1. Apply approximately 1 volt of a 1000 cycle line-wave to the capacitor of Q1 on the oscilloscope. It will be found that as the level of the input signal is varied, the top of the sine wave will be clipped. If the clipping of each half cycle occurs at approximately the same voltage, the limiter is in balance. If clipping occurs at different levels for the positive and negative half cycles it will be necessary to shunt either R5 or R13 with a trim resistor. Start with a trim resistor with approximately 1 megohm across R5. If this improves the waveform or over corrects it, that is, if excessive clipping now occurs on the opposite side of the cycle, a resistor of appropriate value should be shunted across R5. If, when R5 is shunted by 1 megohm clipping becomes worse, that is, the waveform becomes more non-symmetrical, the resistor should be shunted across R13. Having determined whether it is R13 or R5, which is of too great a value, the exact value for symmetrical clipping can now be obtained by substitution. Once the first limiter is balanced, the generator output can be reduced and the oscilloscope connected to the collector of Q5. The generator signal may now be increased until clipping is observed and the previously described method for determining the location and the value of the trim resistor applied to R32 and R33. This procedure completes the adjustment of the carrier amplifier limiters.





HI Z AMPLIFIER

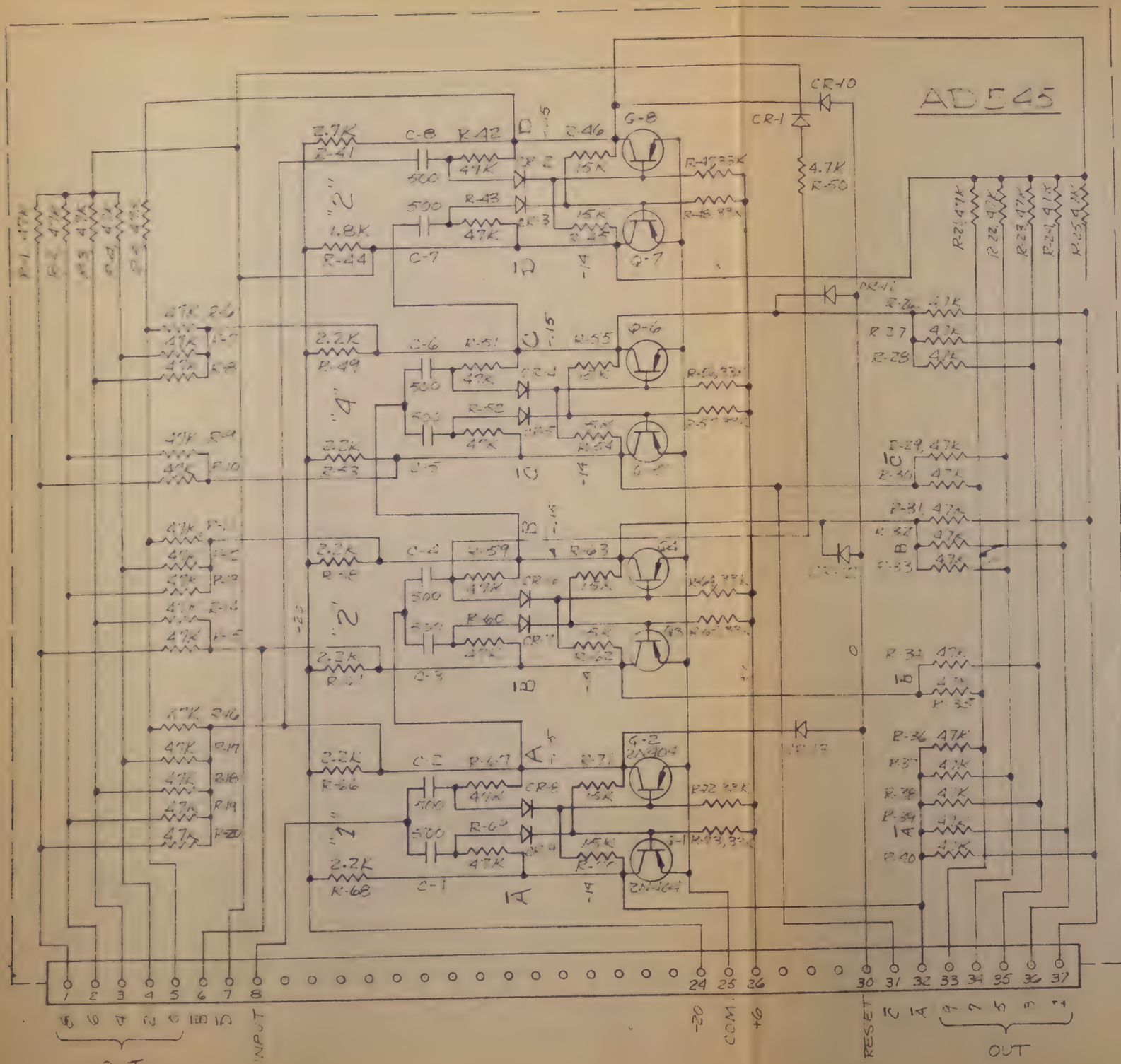
Auto-Data SAN DIEGO, CALIF.

MODELS 2641 2647 2643 2643 2673

8/17/62

DR. CK.

MODEL DEC. ± .005 DWG. NO. AE-1183 ISSUE C



CODING

	A	B	C	D
0				
1	$\bar{A}$ 1	B	C	D
2	A	B	C	$\bar{D}$ 2
3	$\bar{A}$ 1	B	C	$\bar{D}$ 2
4	A	$\bar{B}$ 2	C	$\bar{D}$ 2
5	$\bar{A}$ 1	$\bar{B}$ 2	C	$\bar{D}$ 2
6	A	B	$\bar{C}$ 4	$\bar{D}$ 2
7	$\bar{A}$ 1	B	$\bar{C}$ 4	$\bar{D}$ 2
8	A	$\bar{B}$ 2	$\bar{C}$ 4	$\bar{D}$ 2
9	$\bar{A}$ 1	$\bar{B}$ 2	$\bar{C}$ 4	$\bar{D}$ 2

NOTES:

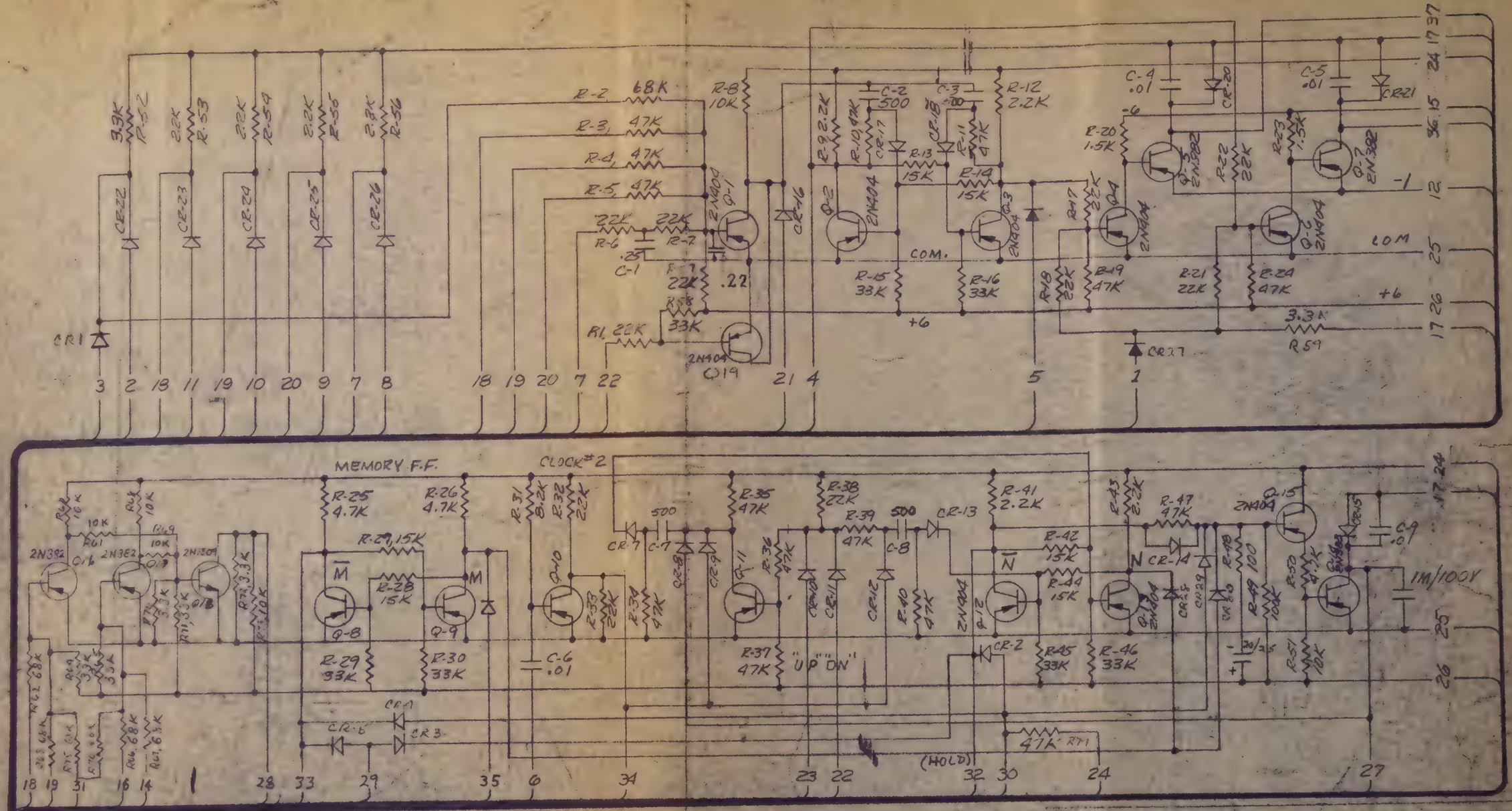
1. [illegible]
2. VOLTAGES ±20%
3. VOLTAGES MEASURED [illegible]

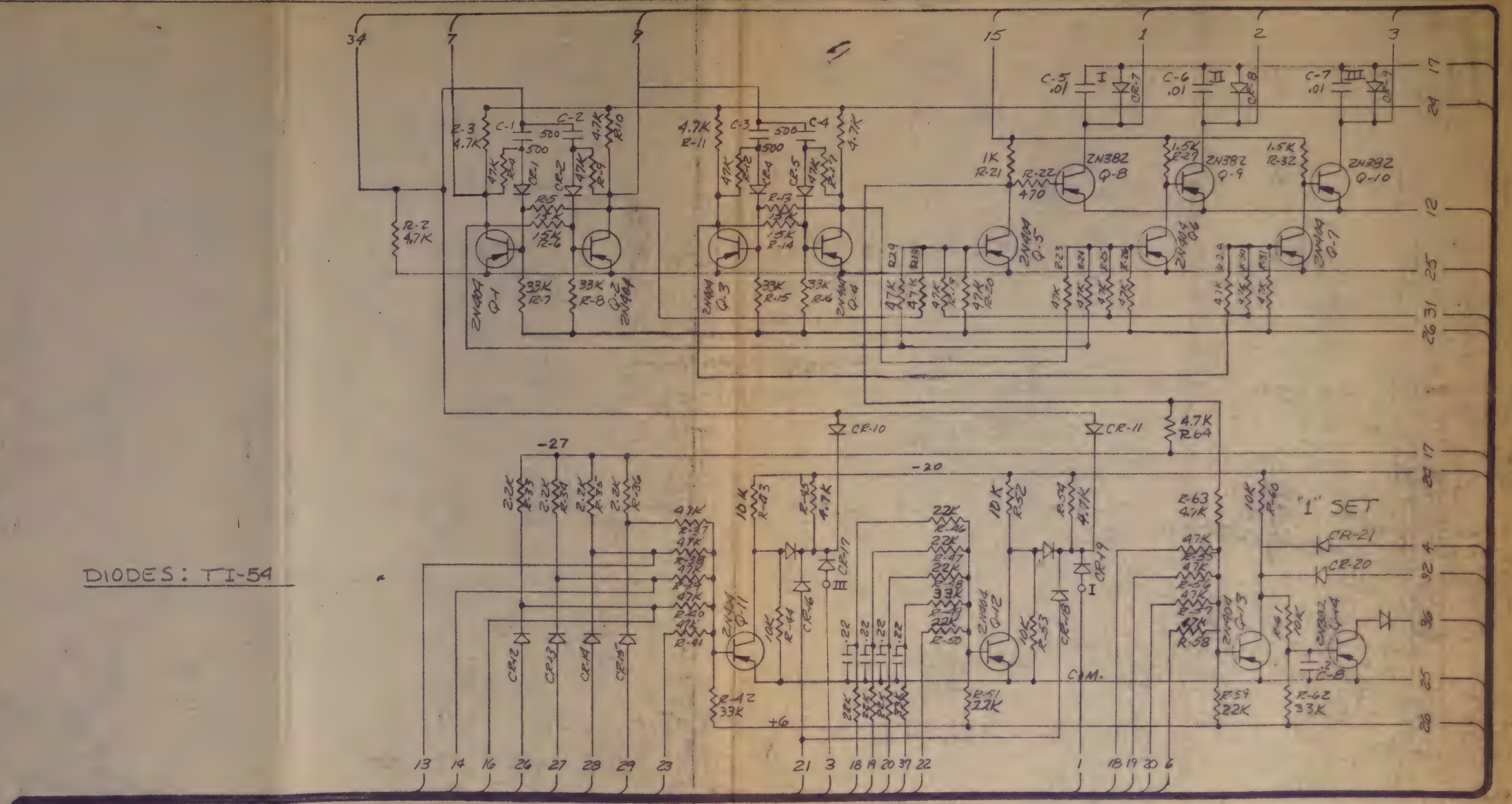
SCHEMATIC-FLIP FLOP BOARD
MODEL 2600 SERIES

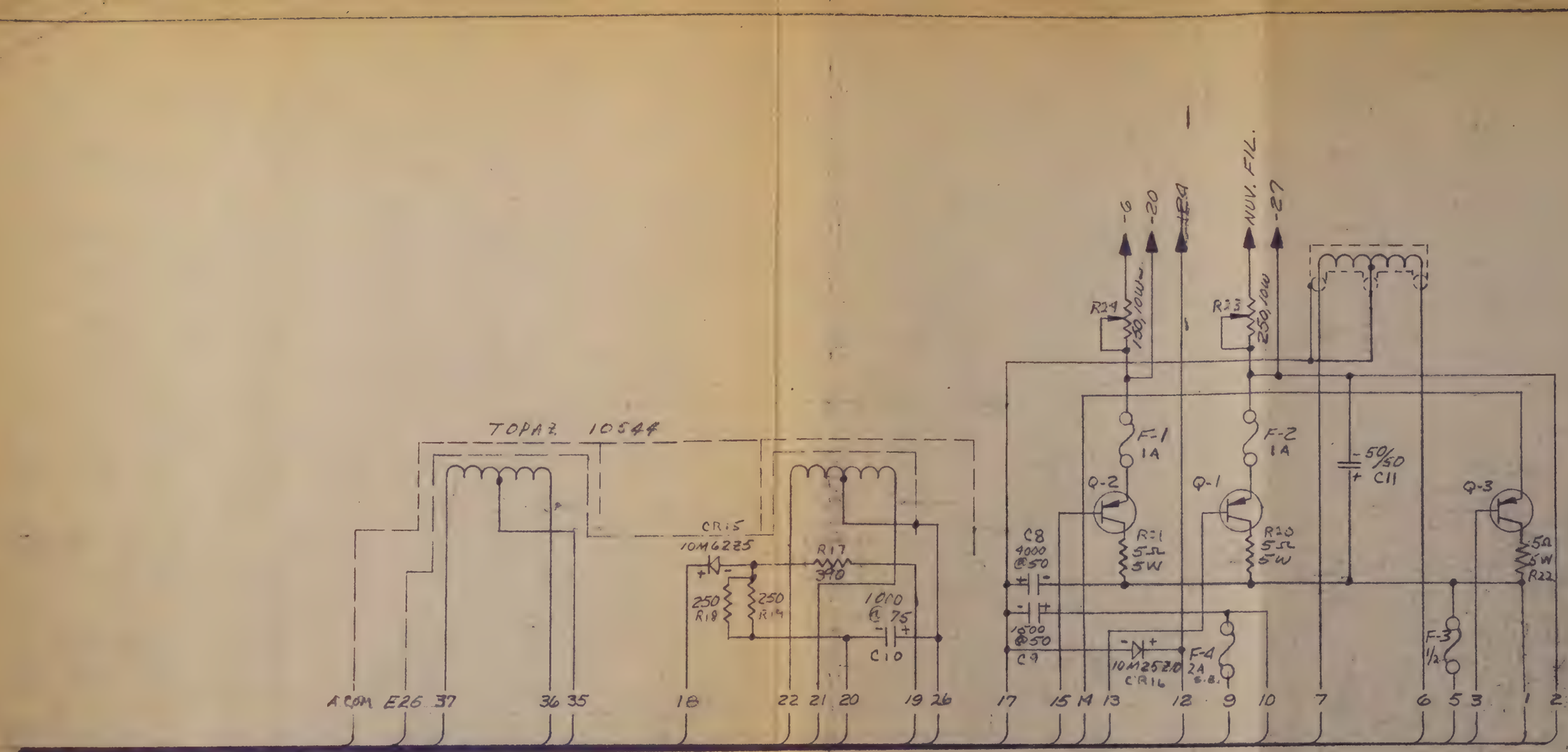
Adm-Data [illegible] FLIP

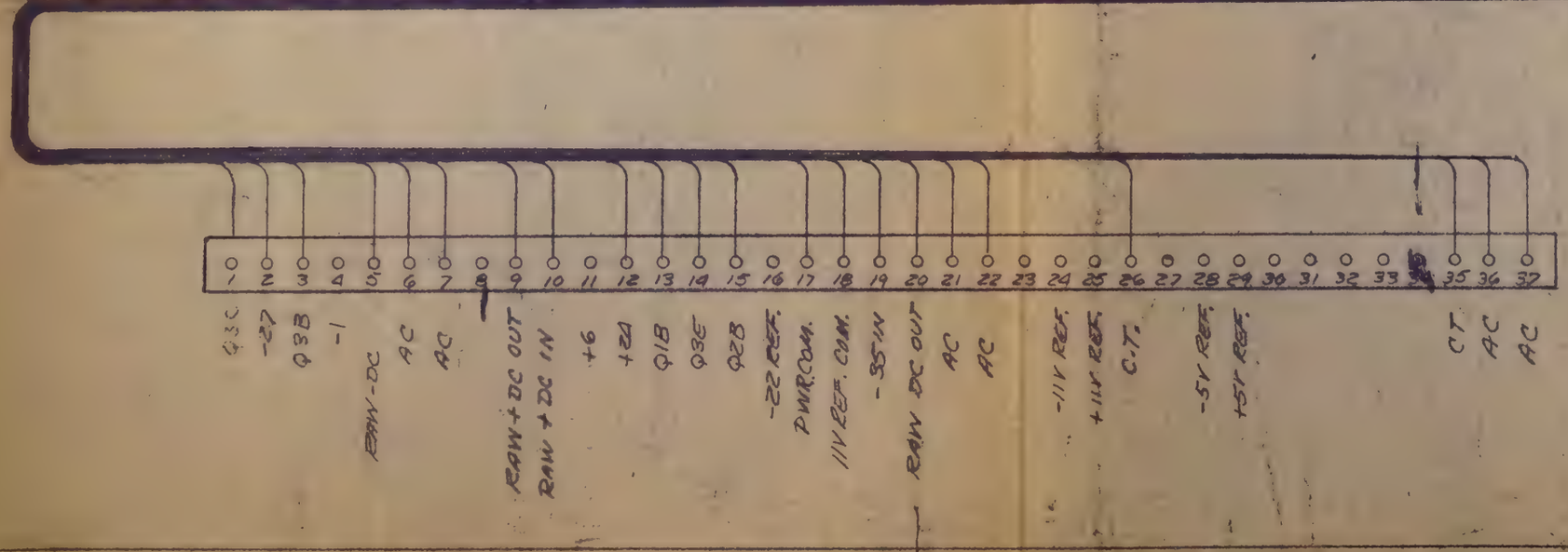
7-21-61

BE-633 A


MEMORY F.F.
CLOCK #2
R-1 10K
R-4 10K
R-25 4.7K
R-26 4.7K
R-31 8.2K
R-32 22K
R-35 47K
R-38 22K
R-39 47K
R-41 2.2K
R-43 2.2K
R-47 47K
R-42 15K
R-44 15K
R-29 15K
R-28 15K
R-27 15K
R-2 68K
R-3 47K
R-4 47K
R-5 47K
R-6 22K
R-7 22K
R-8 10K
R-9 2.2K
R-10 47K
R-11 47K
R-12 2.2K
R-13 15K
R-14 15K
R-15 33K
R-16 33K
R-17 22K
R-18 22K
R-19 47K
R-20 1.5K
R-21 22K
R-22 22K
R-23 1.5K
R-24 47K
R-29 33K
R-30 33K
R-33 22K
R-34 47K
R-36 47K
R-37 47K
R-40 47K
R-45 33K
R-46 33K
R-48 100
R-49 10K
R-50 47K
R-51 10K
R-52 3.3K
R-53 22K
R-54 22K
R-55 22K
R-56 2.2K
R59 3.3K
C-1 .25
C-2 500
C-3 500
C-4 .01
C-5 .01
C-6 .01
C-7 500
C-8 500
C-9 .01
C-10 .25
1M/100V
47K RT1
CR1
CR-2
CR3
CR-5
CR-6
CR-7
CR-8
CR-9
CR-10
CR-11
CR-12
CR-13
CR-14
CR15
CR16
CR17
CR18
CR19
CR20
CR21
CR22
CR23
CR24
CR25
CR26
CR27
CR29
Q-1 2N404
Q-2 2N404
Q-3 2N382
Q-4 2N382
Q-5 2N382
Q-6 2N404
Q-7 2N382
Q-8
Q-9
Q-10
Q-11
Q-12 2N404
Q-13 2N404
Q-14 2N404
Q-15 2N404
Q16 2N382
Q17 2N382
Q18 2N382
Q19 2N404
COM.
+6
-6
-1
-20
M
N
(HOLD)
"UP" "DN"
3 2 18 11 19 10 20 9 7 8
18 19 20 7 22
21 4
5
1
18 19 31 16 14
28 33 29
35 6 34
23 22
32 30
24
27
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
+20 V
-20 V
+6
-6
-1
-20
COM.
NULL
SDF OUTPUT
PRINT (START)
TRACK
SDF MARKER
CLAMP OUTPUT
CLAMP OUTPUT
CLOCK #2
HOLD MAN.
CLOCK
DV
UP
DN
BO
CO
DO
RESET
BL. OSC. IN
POL. SET
E1'
E1
E0
TITLE
POLARITY & NULL DETECTOR BOARD
MODEL 5643, 2654, 2640P
Auto-Data
SAN DIEGO, CALIF.
8-18-62
BE834


DIODES: TI-54
RANGE BOARD
MODEL 2600 SERIES
Auto-Data
1-13-62
BE935
"1" SET
COM.
+6
-27
-20
RESET
HOLD
MAIN RANGE
1000 SET





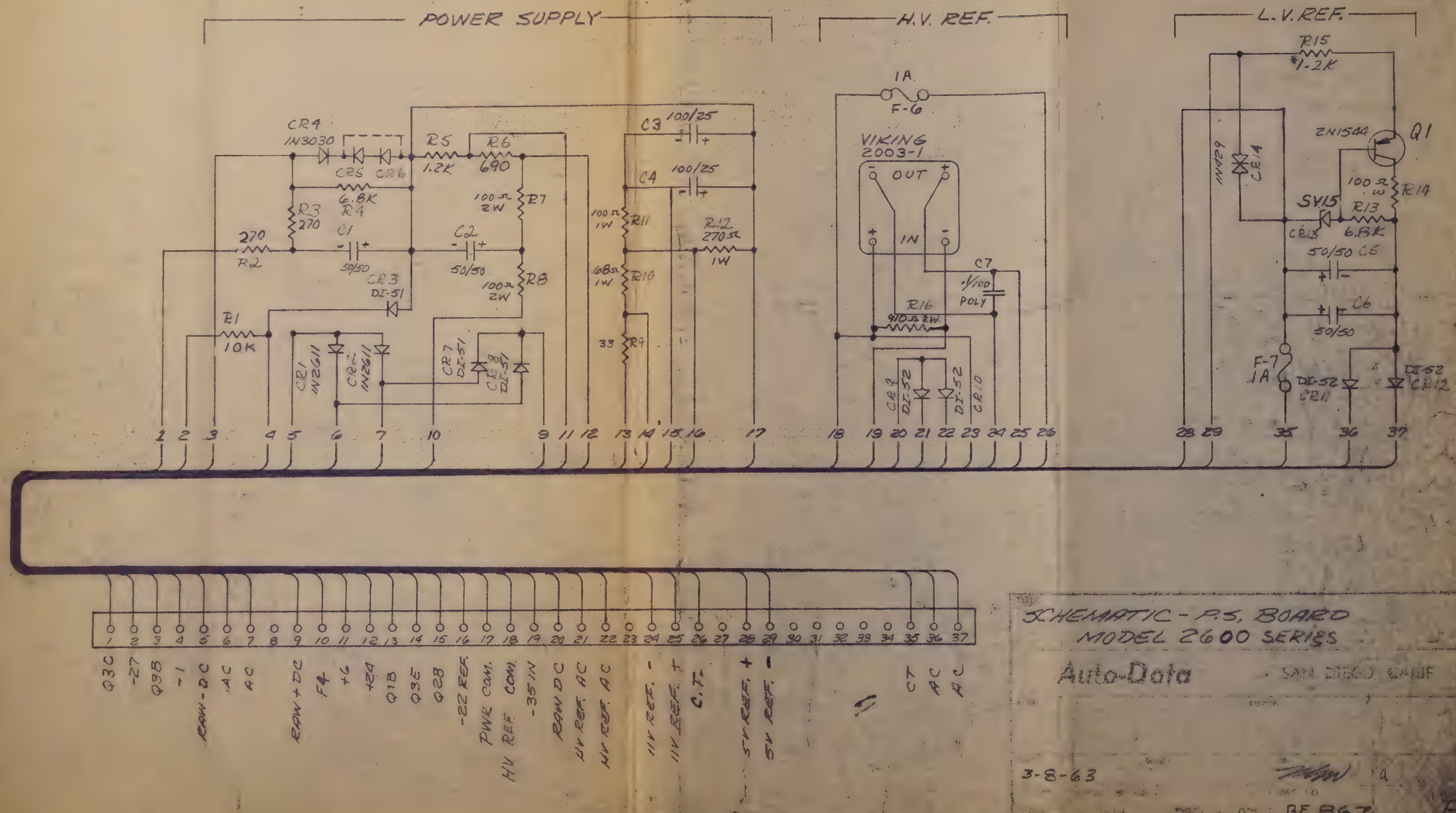
SCHEMATIC - P.S. CHASSIS
MODEL 2600 SERIES

Auto-Data SAN DIEGO, CALIF.

3-8-63

BE 866

Note: * Deposited carbon

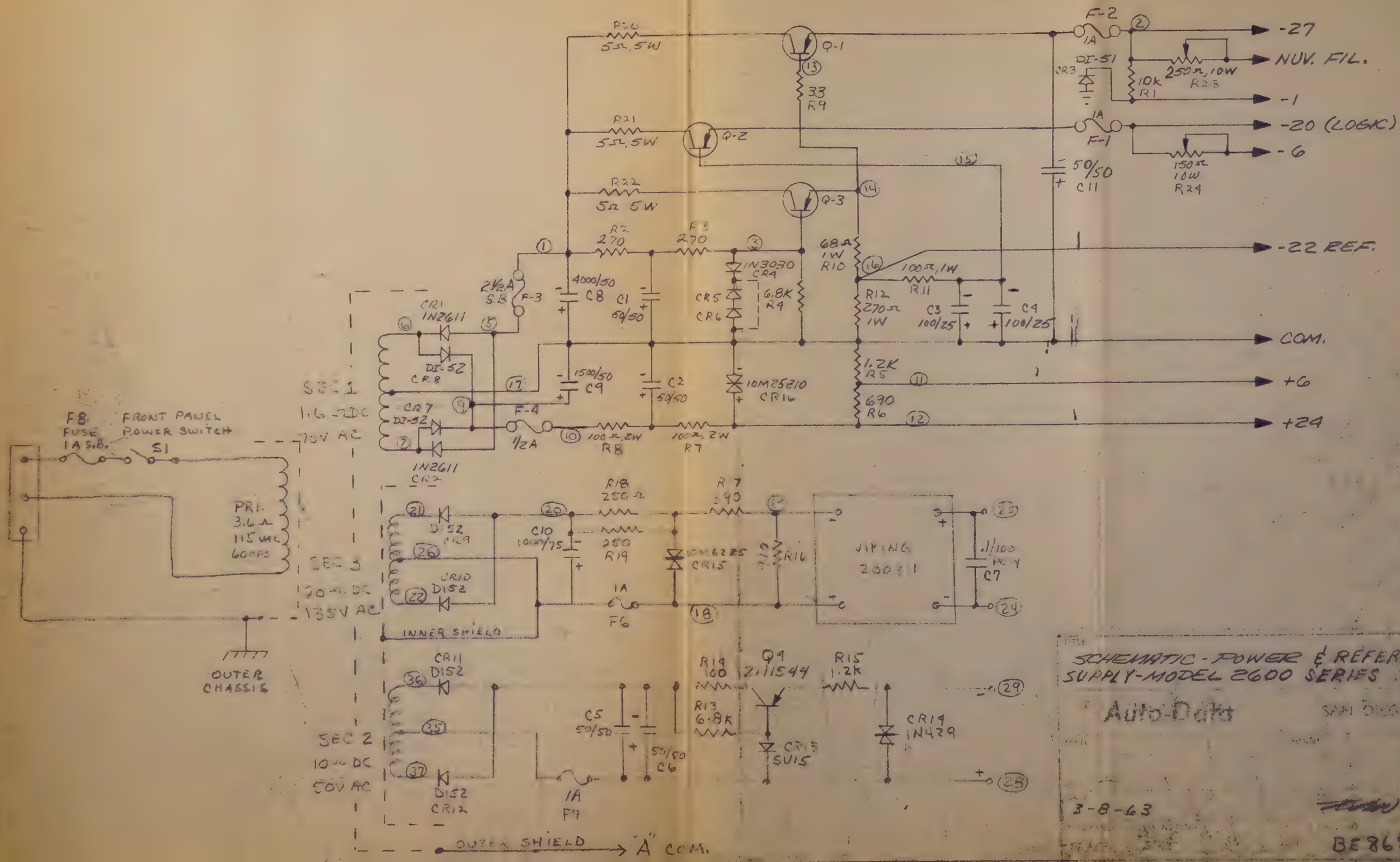


SCHEMATIC - P.S. BOARD
MODEL 2600 SERIES

Auto-Data — SAN DIEGO, CALIF

3-8-63

DWG. BE867 E

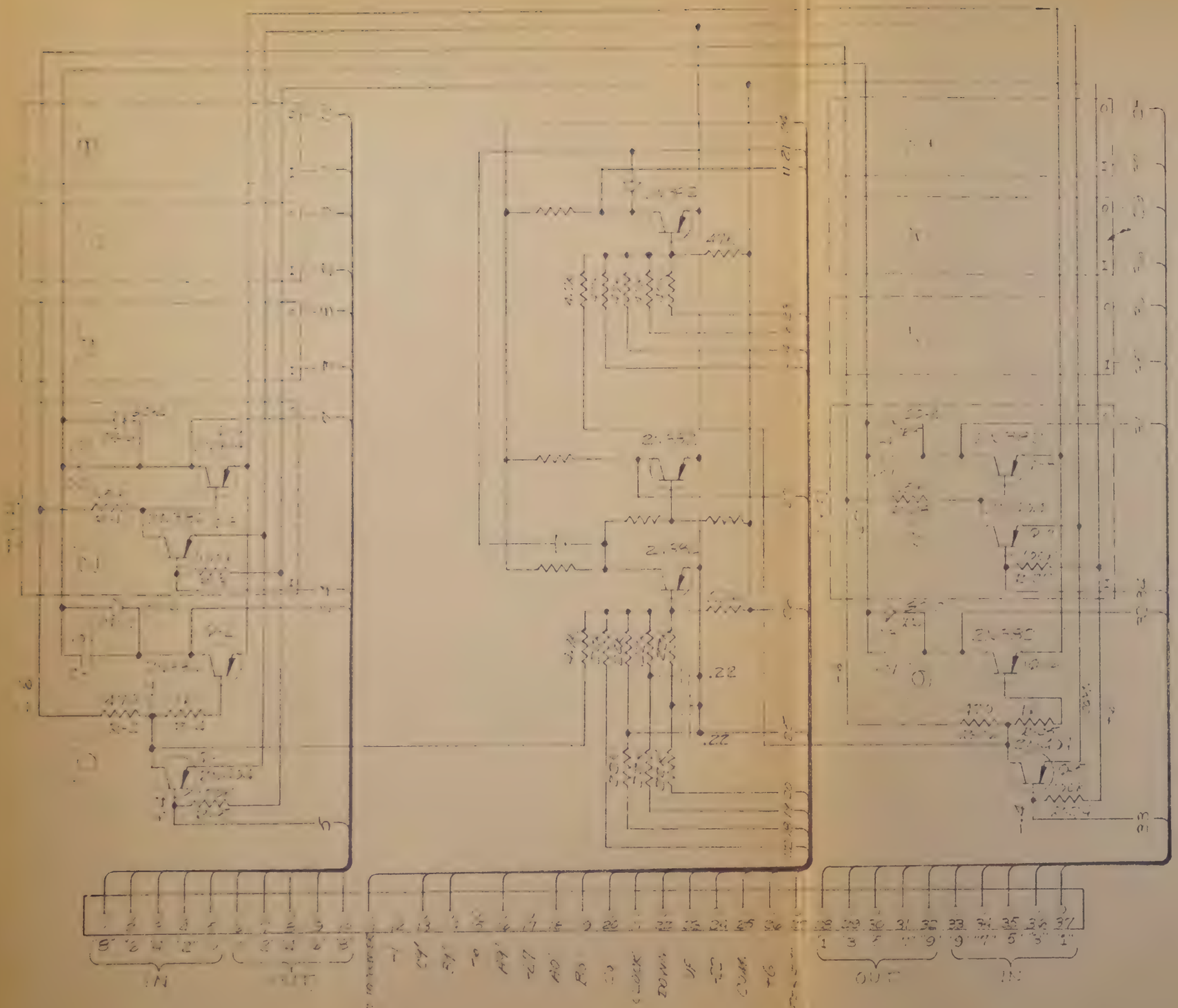


SCHEMATIC - POWER & REFERENCE SUPPLY - MODEL 2600 SERIES

Auto-Data SAN DIEGO, CALIF.

3-8-63

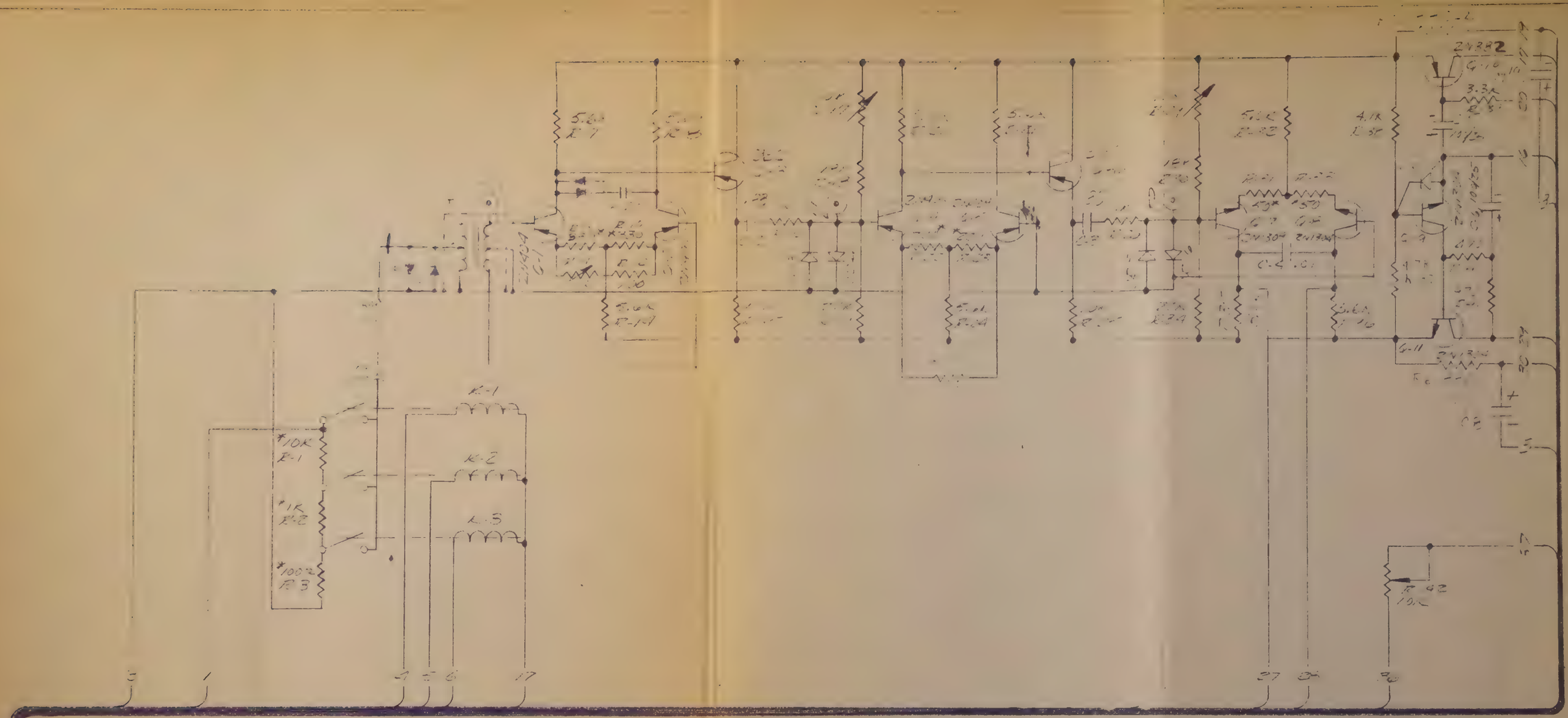
BE868



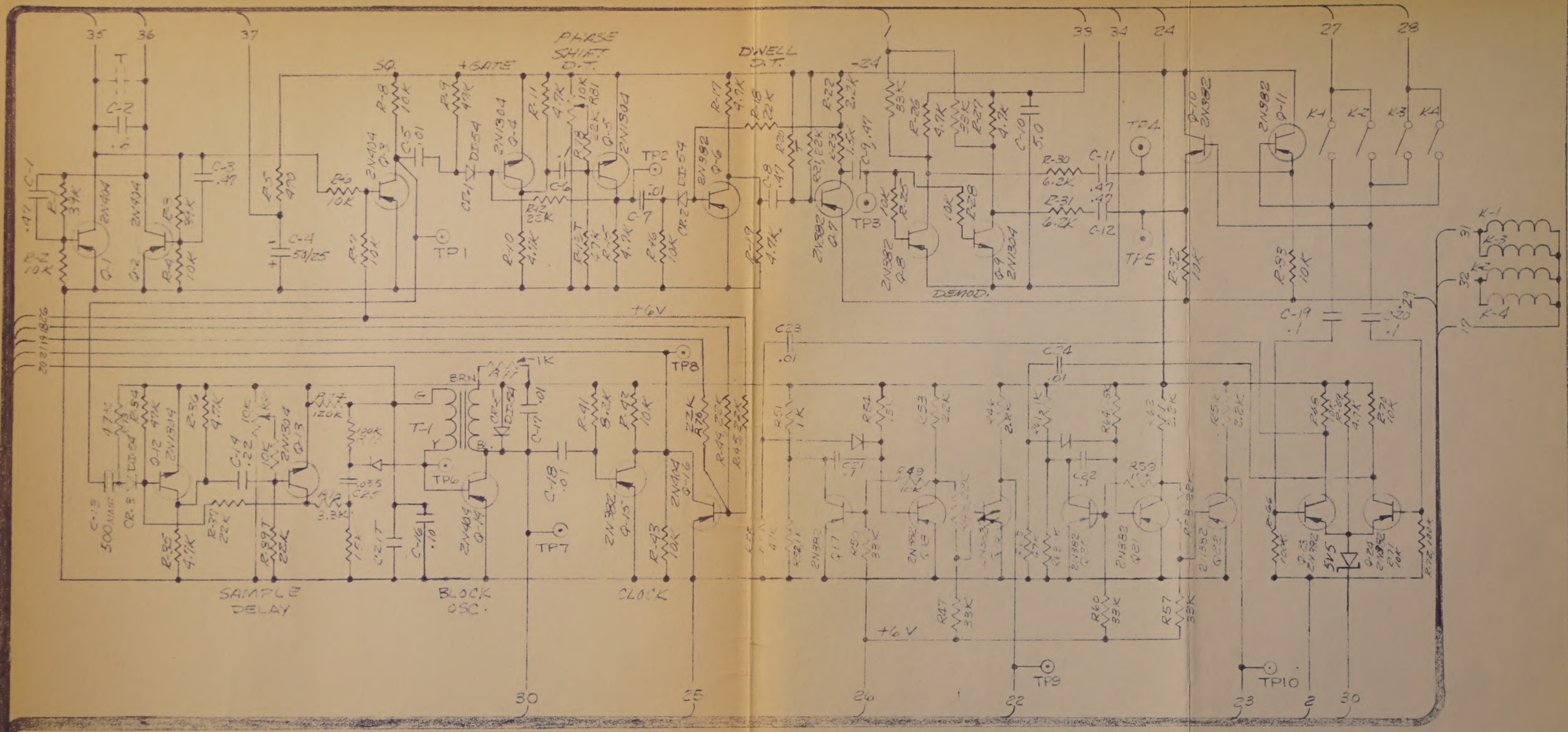
SCHEMATIC - DRIVER BOARD
MODEL 2100-SERIES

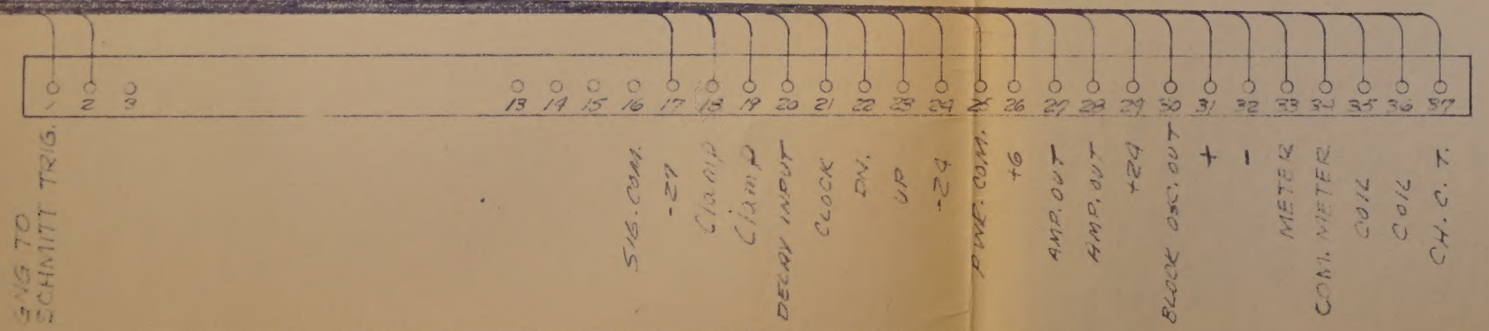
2-9-62

BE-8V0 A


K-1
K-2
K-5
*10K R-1
*1K R-2
*100Ω R-3
R-42 10K
DIODES IN-54
*SHOWN FULL LOAD

BE 805 C





SCHEMATIC - LOGIC DRIVE CIRCUITS
MODEL 2600 SERIES, 5643

Automatic Data

6-19 62

BE 1270

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